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ABSTRACT

Many are concerned that America will not have a sufficient supply of scientists and engineers in the workforce for the 21st century. To aid in increasing the number of students choosing careers in science and engineering, several math and science academies are recruiting underrepresented groups into these areas of study. This document provides a brief overview of two different approaches taken to increase the number of minorities and women choosing science as a career and the barriers that prevent women and minorities from attaining these careers. (ZWH)

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Getting Women and Minorities into the Engineering Pipeline: Pre-College Training in State Math and Science Academies

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Summary

Concerned with having a sufficient supply of scientists and engineers in their twenty-first century workforce, states are encouraging female and minority students to pursue these careers. Statewide math and science academies are one way states bring underrepresented groups into and move them along the science and engineering pipeline. Students at these academies receive accelerated education in math and science, and nonenrolled students often benefit from academy outreach programs. Most academies offer women and minorities special programs that address their needs from the time they apply to the academy to their transition to college.

California and Michigan have taken alternative approaches to getting more women and minorities into the pipeline. Five years ago Los Angeles area school districts joined with California State University at Dominguez Hills to launch the California Academy of Math and Science (CAMS). CAMS is a four-year high school that specifically targets underrepresented groups for math and science careers. In Michigan, all students from grades kindergarten to twelve benefit from the state's math and science centers. Each of these centers serves a region with outreach programs in areas such as teacher training, curriculum development, and mentoring programs. Also, some math and science centers offer special half-day programs for Michigan high school students that are academically talented and/or have a strong interest in math and science.

Background

Facing a projected shortage of 560,000 science and engineering professionals by the year 2010, states have begun to explore ways to address this crisis. Due to demographic trends, the traditional pool of engineers, white males, is shrinking. To remain economically competitive in a technological world, attracting women and minorities to science and engineering professions is becoming an increasing imperative for states.

Increasing the Supply of Women and Minority Engineers: An Agenda for State Action, a report produced from a National Governors' Association (NGA) study undertaken with cooperation and support from the National Science Foundation (NSF), reviewed the potential shortage of science and engineering professionals and identified short-term actions that Governors could take to increase the number of women and minority students entering these fields. Two ensuing papers, *Realizing the Potential of Women and Minorities in Engineering: Four Perspectives from the Field*, and *Recruiting and Retaining Women and Minority Engineering Students: The Role of Teacher Training and Faculty Development*, noted some model programs that illustrate the action agenda in practice. Many of the programs described in these two reports included efforts to both get and keep more women and minorities in the science and engineering pipelines.

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One of the key opportunities to impact career decisionmaking for women and minorities is at the high school level. A longitudinal study conducted by the Department of Education and NSF followed the high school classes of 1972, 1980, and 1982 and found that between the sophomore and senior years in high school, the number of minorities considering careers in science and engineering drops by approximately 25 percent. For white students, the study found the pool decreased by 19 percent. An appropriate intervention is helping high school students think about pursuing a college major in science and engineering. With advanced coursework in math, science, and engineering, high school students may be more likely to succeed in these subjects in college.

Some of the recommendations for Governors outlined in *Increasing the Supply of Women and Minority Engineers* focused on efforts at the high school not only to prepare students for college studies, but also to increase the flow of women and minorities into the engineering pipeline. Specifically, the report makes the following recommendations.

- Improve the study of mathematics and science in the elementary and secondary grades for all students and provide programs targeted to women and underrepresented minorities.
- Encourage the establishment and expansion of programs that specifically encourage more women and minorities to pursue careers in engineering.
- Develop programs to improve faculty awareness of the needs of women and minority students at both the pre-college (and college) level.

Specifically, these items call for gubernatorial action in both the demand for advanced math and science skills and the supply of qualified teachers. On the demand side, eliminating the tracking of students by ability would enable all students to receive advanced math and science training. Governors also can support programs designed to interest young women and minorities in math, science, and engineering and prepare them for college training. On the supply side, Governors can encourage programs that will attract teachers to math and science subject areas and encourage their continuing professional development (for more details see *Recruiting and Retaining Women and Minority Engineering Students: The Role of Teacher Training and Faculty Development*). Another way to increase the supply of qualified teachers is to allow alternative teaching certification to enable practicing or retired scientists and engineers to teach math and science at the K-12 grade level.

The report also urges Governors, when taking steps to encourage women and minorities to pursue science and engineering careers, to work with the private sector, parents, teachers, and counselors to educate students about the opportunities in math, science, and engineering fields. These key groups also can join together to form a statewide cooperative effort that will support pre-college students' interest in the mathematics and sciences with encouragement, training, and financial assistance as necessary.

High School Interventions

One of the barriers that prevents women and minorities from attaining engineering degrees is poor academic training. Studies have revealed that women and minorities are underrepresented in advanced science and math classes. Also, women and minorities historically achieve lower scores on standardized tests in math and sciences, often because they lack sufficient academic preparation and achievement. For example, curricular deficiencies may inadvertently discourage women and minorities from higher achievement. Other factors include insufficient teacher training (in subject matter, teaching methodology, and cultural/gender sensitivity), lack of female and minority professional role models, inadequate course offerings in advanced science and math, poor laboratory facilities, and classroom tracking practices.

These and other factors tend to decrease the number of women and minorities getting into the engineering pipeline. To address these barriers, several states have instituted math and science academies that provide advanced training at the high school level. These academies prepare students to pursue college studies in science, math, and engineering. In addition, most academies have programs to disseminate new curricula, train teachers, and provide supplemental educational seminars to nonacademy students. Many of the programs in math and science academies formally or informally provide a supportive and encouraging environment for women and minorities in their study of math and science.

Overview of State Math and Science Academies

Most math and science academies are residential high schools for juniors and seniors that offer advanced coursework in math and science and encourage careers in science and engineering. Many of these schools provide courses in math and sciences that the students otherwise would not be able to access. Often, these courses are not only academically advanced, but also incorporate experimental curricula and teaching methods. To support these course offerings, most academies have an above-average ratio of faculty members holding doctorates who can use university, or university-level, facilities.

Some of the academies also offer honors-level courses in the humanities, arts, and social sciences. These courses help students develop a broader understanding and appreciation for the world in addition to strengthening important skills such as writing, communication, and interpersonal relations. Interdisciplinary learning enriches the technical and social science curricula by demonstrating how mathematics and sciences impact many aspects of everyday life. Nearly all academies have students working on independent research efforts, often with an interdisciplinary component.

In addition to their regular school-day schedules, the academies offer enrichment programs. Some academies have their faculty lead special study sessions or give evening tutorials; others have occasional seminars or field trips on Saturdays. At the **Illinois Mathematics and Science Academy** (IMSA), every sixth school day is reserved for students to participate in special activities, including site visits, mentoring programs, and individual or group research projects. Also, students frequently have the option of taking courses at a nearby (or affiliated) university, thus acquiring college credit as they earn their high school diploma. In fact, at the **Texas Academy of Mathematics and Science** (TAMS) students take all of their courses at North Texas University.

Generally, the admissions process is very competitive. Most academy officials select incoming students by traditional academic measures, such as grades and standardized test scores, as well as their interest in science or math (often demonstrated by a project) and their potential as assessed by current instructors, counselors, and academy officials in personal interviews. A common goal is to have the incoming student body represent a broad spectrum of demographics, thereby insuring the participation of women and minorities.

Academy programs also work to develop students' leadership skills. Many academies require that students work a certain number of hours on campus and/or in the community in order to graduate. Mentoring programs provide "real people" role models who individually foster students' personal and professional development. And typical extracurricular activities, such as athletics, school publications, or class government, provide opportunities for students to develop leadership skills and become well-rounded individuals.

States often support the academies as a key investment in their future. The **North Carolina School of Science and Mathematics** (NCSSM) in particular has tracked the state's investment. In its 1990 annual report, NCSSM reported that 80 percent of the 1982-89 NCSSM graduates had college majors in science and engineering and that more than half of nonmilitary NCSSM alumni stayed in North Carolina to work. The study did not determine how the academy's outreach efforts (e.g., teacher training, curriculum models, and video links) impacted non-NCSSM student academic performance or career decisions.

Academies Focus on Women and Minorities

Most academies gear their recruitment and admissions processes to attract a student body that represents the state demographics (without solely making decisions based on ethnicity, gender, or residence). In order to build diversity, admission offices have instituted a number of programs. At the **Indiana Academy for Science, Mathematics, and Humanities**, the admission staff focus on attracting minority candidates at an early age (often at the seventh and eighth-grade level) and on counseling minority applicants through the admissions process (e.g., through seminars and other special programs specifically for prospective minority students). IMSA publishes one of its brochures in Spanish, and its "Student Ambassador Program" pairs prospective applicants with current IMSA students. The **South Carolina Governor's School for Science and Mathematics** (GSSM) has a staff director for minority recruitment and retention who works with predominantly black schools and school districts as well as with counselors to emphasize the importance of getting minorities into the math and science pipeline.

Using other recruitment strategies, some academies offer summer programs for pre- or early high school students. The GSSM's "Summer Science Program" brings academically gifted ninth graders to GSSM for three weeks with subsequent follow-up activities (during the academic year) at colleges or universities near the students' hometowns. Approximately 30 percent of Summer Science Program participants are minorities, and a quarter of all program participants later become GSSM students. Although all gifted and talented students can participate in GSSM's Summer Science Program, an MSMS summer program, "Project 500," specifically targets African-Americans. Project 500 brings in students from eighth to eleventh grade for a week at MSMS. In addition to advanced math and science classes, Project 500 offers courses that give an overview of engineering, help students think about careers and prepare for the college entrance exams, and study African-American literature, wellness, and public speaking. State and local African-American leaders interact with students, providing them with role models and guidance.

The **Oklahoma School of Science and Mathematics** (OSSM) encourages its students to participate in statewide "Summer Academies" sponsored by the Ok-

lahoma State Regents for Higher Education. These academies are free, hands-on workshops that, over a period of one to four weeks, help students in grades eight through twelve explore the changing frontiers of math and science. Most of the academies have open enrollment, but a few are only for women and minorities. In another special summer program for minorities in Oklahoma, the "Summer Research Apprentice Program," students work in research laboratories at the University of Oklahoma Health Sciences Center campus. This program not only gives the students research experience, but also pays a small stipend. The **Pennsylvania Governor's Schools of Excellence** (PGSE) offers students similar opportunities in summer programs not only in math and science, but also in the arts, international studies, and teaching.

Many of the academies have developed programs to address the special needs of minority students. The most common efforts emphasize multi-cultural education through curriculum development, women and minority faculty recruitment, and special cultural events. These efforts can help students and faculty become more sensitive to and develop an appreciation for cultural differences. Several academies also have an on-site counselor who works with women and minorities. IMSA illustrates still another approach. Incoming IMSA students that are at-risk (because their academic or social environment did not provide them with adequate preparation for advanced studies) can attend a three-week summer program called EXCELL. This program gives students special academic and personal attention to ease their transition from high school to IMSA. EXCELL participants also can elect to participate in follow-up services during the academic year such as tutoring, academic intervention, cultural enrichment, and student support networks.

Fostering gender sensitivity is a goal at many of the academies. At TAMS, female students participate in panels that regularly discuss issues women face in schools and workplaces such as discrimination and sexual harassment. At least two other schools, IMSA and OSSM, are experimenting with gender-specific classes. Although these courses use the same content and have the same expectations of students as integrated classes, different student-to-student interaction and a separate learning environment may help female students gain more confidence in their scientific and mathematical capabilities.

Mentoring programs that pair students with professionals are also common. Mentors can play an especially important role in keeping women and minorities in the pipeline by providing successful role models who can offer guidance and encouragement. Most mentors meet with or talk to their students at least once a week, and also may attend special events with them. Some mentoring programs even combine the role modeling components with apprenticeships or internships that provide students with hands-on work in their field of interest.

All of the state academies have outreach programs to raise the quality of math and science education outside the academies. Although most outreach programs do not target women and minorities, many begin to address the barriers these students face in obtaining adequate preparation for science and engineering college majors. These outreach programs include dissemination of information about academy experiments in teaching methodology, gender-specific classes, and advanced math and science curriculums designed to encourage women and minorities. Through telecommunication linkages, students in remote or impoverished school districts can participate in advanced academy courses. Academy-sponsored training sessions are another outreach effort that educates teachers and counselors about special problems facing women and minorities in school and in the workplace. Finally, many academies have programs such as IMSA's "Challenge" program that are designed to encourage and prepare students in grades seven through nine, especially those from underrepresented groups, to enroll in academically challenging programs.

The state science and math academies mentioned above have many commonalties. The following are two alternative models states can use when considering how to address science and engineering shortages through recruitment and retention of women and minorities in math, science, and engineering.

Case Study: California Academy of Math and Science

The **California Academy of Mathematics and Science** (CAMS) is a comprehensive, public, four-year high school serving students in the Los Angeles area. CAMS is a joint project of the California State University and the Long Beach and Compton Unified School Districts. Students are drawn from sixty southern California schools with a recruitment pool of 25,000 eighth graders. The school is located on the campus of California State University at Dominguez Hills (CSUDH).

The academy receives the same state allocation as any public school, though additional funding has been obtained from corporations and foundations. In 1993 approximately 20 percent of the school's operating budget came from industry sources. School faculty are drawn from the participating school districts. CAMS recruits teachers from public schools on one-year contracts for a maximum of five years so that when they return to their home schools, they can bring new approaches to teaching math and science. CAMS students are eligible to enroll in

CSUDH courses as part of their regular class schedules with the expectation that most will graduate with up to a year's worth of college credit.

One way that CAMS differs from other state academies is that its mission explicitly includes bringing more women and minorities into the fields of math, science, and engineering. The academy has been successful in recruiting a student body that mirrors the demographics of the Los Angeles area. In 1993 the student body was 28 percent Hispanic, 28 percent African American, and 18 percent underrepresented Asian (Cambodian and Vietnamese, etc.). Approximately 52 percent of the students are female. Many come from low-income homes. Often, these students are the first in their family to attend college.

CAMS is also different because students come from a broader academic range—the top 30 percent of their class—than other state academy students who are in the top 5 percent. In addition to their academic record, students recruited for CAMS have a demonstrated interest in math and science and a strong motivation to succeed in an accelerated academic program. By recruiting a broad academic range, CAMS may encourage more students—especially underrepresented groups—to consider science and engineering careers, particularly since women and minorities historically have lower math and science scores on standardized tests.

In 1992 CAMS received a small grant from NGA's Women and Minorities in Science and Engineering project, funded by NSF, to develop a pre-engineering course. This Survey of Engineering course provides freshmen and sophomores with an overview of careers in engineering (through guest speakers from industry and universities, university undergraduate handbooks, and corporate literature) in the fall semester. The spring semester involves these students in research projects that give them direct experience with engineering work. Through classroom activities and its mentoring program, which pairs all students with industry mentors and selected university professionals, CAMS uses this course to encourage women and minorities to consider a career in engineering.

A related component to the Survey of Engineering course, also funded in part by the NSF, is a tour of colleges for juniors. These tours enable students to compare facilities, receive guidance on applications and financial aid, and learn about science and engineering majors. After the first set of tours, participating students reported that they had a better appreciation for mathematics and science and more confidence in making the transition from high school to college. CAMS plans a second round of tours in 1994, taking junior "graduates" of the Survey of Engineering course to Northern California colleges and universities, while the remaining members of the junior class will tour local schools. Because CAMS' teachers feel that the tours are an essential part of preparing students for careers in science and engineering, classes for juniors are suspended for one week so all can participate.

Case Study: Michigan's Mathematics and Science Centers Program

Michigan provides a unique alternative to the state academy for science and mathematics model. Using the **Kalamazoo Area Mathematics and Science Center** (KAMSC) program as a prototype, the Michigan legislature established the **Mathematics and Science Centers Program** to provide students from K-12 with accelerated courses in math and science and to operate outreach programs that will promote educational reform. Building partnerships with local businesses, industry, community groups, and foundations, the program now includes twenty regional centers.

These centers all have different programs so that they can be responsive to their service area; nevertheless, together the centers promote a common vision of systemic reform of math and science education in order to promote the National Education Goals supported by the President and the Governors through changes in curriculum, instruction, and assessment. (In fact, the centers are one component of Michigan's Statewide Systemic Initiative funded by the NSF.) The centers provide basic services by:

- providing leadership in meeting state and national educational goals;
- serving students with accelerated or enhanced math, science, and technology education;
- supporting the development of curriculum;
- involving their communities to build support for progressive educational programming;
- offering professional development to strengthen teaching practices; and
- serving as a resource clearinghouse (along with institutions of higher education).

Unlike many state academies that provide full-time instruction, some of the math and science centers in Michigan offer time-share programs for academically talented students and those with a high interest in math and science and impact all students through their extensive outreach activities. Because the centers are regional, some provide services in districts that have large proportions of minorities. The centers have a commitment to serving underrepresented groups and most make special efforts to meet their needs by hiring female and minority faculty, by

developing multicultural curricula, and by offering programs that target female and minority students.

KAMSC typifies many of the kinds of programs offered by the centers. It operates an on-site program for high school students and sponsors community outreach efforts. Most of KAMSC's students enter as freshmen and spend half of each school day at KAMSC for their math, science, and technology courses for four years. (The KAMSC time-share design is based on a study that indicated that pullout programs show improved academic performance for both students participating in a pullout program and their peers who remain on a routine schedule.) The student body of 300 comes from 14 Kalamazoo area high schools and are selected by their entrance exam performance and other standardized test scores, past grades, and writing samples. The core curriculum includes interdisciplinary studies, computer studies, science, and integrated mathematics and calculus, and students have opportunities to participate in a senior mentorship program and to pursue specialized topics through electives or independent research. KAMSC also sponsors a number of career education events such as field trips, career days, and work-study programs.

KAMSC has several programs geared to women and minorities. In its recruitment efforts, KAMSC takes an aggressive approach. Information nights, held in predominantly minority neighborhoods, use women and minority scientists as presenters and role models. Another recruitment effort is an annual girls' conference in which female role models from the community discuss their work and careers in math and science fields. Using the "talent pool development model," KAMSC, through a W.K. Kellogg Foundation grant, provides materials to and training for teachers in order to help them encourage underrepresented groups' entering math and science careers. Finally, an on-site counselor assists students who face obstacles to completing their studies at KAMSC.

In addition to its programs for enrolled students, KAMSC has several outreach programs that involve students at other schools, teachers throughout the community, and community-based efforts. KAMSC students can take an elective course in which they develop and make science presentations in elementary classrooms. A summer program operating at three locations gives approximately 1,000 area students a choice of 50 courses, and KAMSC sponsors periodic student conferences and Saturday morning science seminars. Teachers can take workshops, borrow videotapes for training, or spend a sabbatical semester at KAMSC to work on aspects of math or science education. KAMSC involves the community through its mentorship program and leadership in the formation of the Southwest Michigan Math/Science Alliance, which produces a community resource guide and assists high schools in developing a mentorship program.

Michigan's Math and Science Center Program, through active support from the private sector, local school districts, and communities, is able to have a broad impact with a relatively small state investment. In the 1992-93 academic year, the state provided more than $2.3 million in competitive grants to the centers. With an additional $4.3 million in nonprogram funds, these centers served more than 90,000 students and nearly 21,000 teachers in 370 school districts.